STACK EMISSIONS MONITORING REPORT

SOCOTEC

Unit 20
The Falcon Business Centre
Romford
RM3 8UR
Tel: 01283 554373

Your contact at SOCOTEC UK LTD
[redacted]
Project Manager - Romford
[redacted]
[redacted]

Operator & Address:
Tarmac Ltd
Newhaven Roadstone
North Quarry Road
Newhaven
BN9 0AB
-
-
-

Permit Reference:
DEFRA Process Guidance Note: PG 3/15 (12)

Release Point:
Main Stack

Sampling Date(s):
13th June 2018

SOCOTEC UK Job Number:	LRO1507
Report Date:	27th June 2018
Version:	1
Report By:	[redacted]
MCERTS Number:	[redacted]
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Report Approved By:	[redacted]
MCERTS Number:	[redacted]
Business Title:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Signature:	

UKAS TESTING 1015

MCERTS THE REPORTABLE AGENCY'S MONITORING CERTIFICATION SCHEME

CONTENTS

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Tarmac Ltd operates a roadstone coating process at Newhaven which is subject to DEFRA Process Guidance Note PG 3/15 (12), under the Environmental Permitting Regulations 2010.

SOCOTEC UK LTD were commissioned by Tarmac Ltd to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's DEFRA Process Guidance Note, PG 3/15 (12).

Plant

Main Stack

Operator

Tarmac Ltd
Newhaven Roadstone
North Quarry Road
Newhaven
BN9 0AB
-
-

DEFRA Process Guidance Note: PG 3/15 (12)

Stack Emissions Monitoring Test House

SOCOTEC UK - Romford Laboratory
Unit 20
The Falcon Business Centre
Romford
RM3 8UR
UKAS and MCERTS Accreditation Number: 1015

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	Units	Result	Calculated Uncertainty +/-	Limit	MCERTS accredited result
Total Particulate Matter	mg/m³	32.4	1.5	50	✓
Particulate Emission Rate	g/hr	862.2	38.8	-	
Moisture	%	7.5	0.2	-	✓
Stack Gas Temperature	°C	67	-	-	✓
Stack Gas Velocity	m/s	11.5	0.3	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	32502	1656	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	26248	1337	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	24279	1237	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	26248	1337	-	

ND = None Detected,

Results at or below the limit of detection are highlighted by bold italic text.

The above volumetric flow rate is calculated using data from the preliminary survey. Mass emissions for non isokinetic tests are calculated using these values. For all isokinetic testing the mass emission is calculated using test specific flow data and not the above values.
Reference conditions are 273K, 101.3kPa without correction for water vapour

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	Sampling Date(s)	Sampling Times	Sampling Duration
Total Particulate Matter Run 1	13 June 2018	07:18 - 07:53	32 minutes
Preliminary Stack Traverse	13 June 2018	07:02	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Roadstone coating
Continuous or batch	Batch
Product Details	20mm/dust
Part of batch to be monitored (if applicable)	Any 30mins after start-up
Normal load, throughput or continuous rating	approx 60 tonnes/hr
Fuel used during monitoring	PFO
Abatement	Bag filter
Plume Appearance	Moisture only

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC UK is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency Technical Guidance Note (Monitoring) M2.

MONITORING METHODS						
Species	Method Standard Reference Method / Alternative Method	SOCOTEC UK Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Limit of Detection (LOD)	Calculated MU +/- %
TPM	SRM - BS EN 13284-1	AE 104	1015	Yes	0.58 mg/m³	4.5%
H_2O	SRM - BS EN 14790	AE 105	1015	Yes	0.01%	2.82%
Velocity	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	5 Pa	2.3%
Volumetric Flow Rate	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	-	5.1%

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody and archiving details:

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	UKAS Accredited Lab Analysis	Analysis Lab	Sample Archive Location	Archive Period
TPM	Gravimetric	AE 106	1015	Yes	SOCOTEC UK (Cirencester)	SOCOTEC UK (Cirencester)	8 Weeks

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	MCERTS Accredited Analysis	Laboratory	Data Archive Location	Archive Period
H_2O	Gravimetric	AE 105	1015	Yes	SOCOTEC UK Romford	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	Value	Units	Requirement	Compliant	Method
Lowest Differential Pressure	76	Pa	>= 5 Pa	Yes	BS EN 15259
Lowest Gas Velocity	10.6	m/s	-	-	-
Highest Gas Velocity	12.4	m/s	-	-	-
Ratio of Gas Velocities	1.2	: 1	< 3 : 1	Yes	BS EN 15259
Mean Velocity	11.5	m/s	-	-	-
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes	BS EN 15259
No local negative flow	Yes	-	-	Yes	BS EN 15259

DUCT CHARACTERISTICS		
	Value	Units
Shape	Circular	-
Depth	1.00	m
Width	-	m
Area	0.79	m^2
Port Depth	90	mm

SAMPLING LINES & POINTS		
	Isokinetic	Non-Iso & Gases
Sample port size	4" BSP	-
Number of lines used	2	-
Number of points / line	2	-
Duct orientation	Vertical	-
Filtration for TPM	In stack	-

SAMPLING PLATFORM	
General Platform Information	
Permanent / Temporary Platform / Ground level / Floor Level / Roof	Permanent
Inside / Outside	Outside

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	Yes
Platform has vertical base boards (approximately 0.25 m high)	Yes
Platform has removable chains / self closing gates at the top of ladders	Yes
Handrail / obstructions do not hamper insertion of sampling equipment	Yes
Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m	Yes

Sampling Platform Improvement Recommendations (if applicable)

The sampling location meets all the requirements as specified in EA Guidance Note M1.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

In this instance there were no deviations from the sampling and analytical methods employed.

APPENDICES

CONTENTS

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE					
Species	Method Standard Reference Method / Alternative Method	SOCOTEC UK Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Number of Samples
TPM	SRM - BS EN 13284-1	AE 104	1015	Yes	1
H_2O	SRM - BS EN 14790	AE 105	1015	Yes	1
Velocity	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST

Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	Equipment I.D.	Equipment	Equipment I.D.	Equipment	Equipment I.D.
Control Box DGM	P1799	Horiba PG-250 Analyser	-	Laboratory Balance	-
Box Thermocouples	P1799	FT-IR Gasmet	-	Tape Measure	P2202
Meter In Thermocouple	P1799	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	P1799	Bernath 3006 FID	-	Protractor	-
Control Box Timer	P1799	Signal 3030 FID	-	Barometer	P2748
Oven Box	-	Servomex	-	Digital Micromanometer	P2664
Probe	P2250	JCT Heated Head Filter	-	Digital Temperature Meter	P2045
Probe Thermocouple	P2249	Thermo FID	-	Stack Thermocouple	P1448
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	P2248	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	P1894	Chiller (JCT/MAK 10)	-	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	-	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	-	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-		-	15m Heated Line (1)	-
Heater Controller	-		-	20m Heated Line (1)	-
Inclinometer (Swirl Device)	P2094		-	20m Heated Line (2)	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

CALIBRATION GASES

Gas (traceable to ISO 17025)	Cylinder I.D Number	Supplier	ppm	%	Analytical Tolerance +/- %
-	-	-	-	-	-

STACK EMISSIONS MONITORING TEAM

MONITORING TEAM								
Personnel	MCERTS Number	MCERTS		TE / H&S Qualifications and Expiry Date				
		Level	Expiry	TE1	TE2	TE3	TE4	H&S
[redacted]	[redacted]	MCERTS Level 2	Sep-21	Sep-21	Mar-22	Dec-21	Dec-21	Mar-23
[redacted]	[redacted]	MCERTS Level 1	Aug-21	-	-	-	-	Aug-21

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER SUMMARY					
Parameter	Sampling Times	Concentration mg/m³	Uncertainty mg/m³	Limit mg/m³	Emission Rate g/hr
Run 1	07:18 - 07:53 13 June 2018	32.4	1.47	50	862
Blank	-	0.58	-	-	-

Reference conditions are 273K, 101.3kPa without correction for water vapour

Acetone Blank Value mg/l	Acceptable Value mg/l
2.0	10

FILTER INFORMATION

SAMPLES								
Test	Filter & Probe Rinse Number	Filter Start Weight g	Filter End Weight g	Mass Gained on Filter g	Probe Rinse Start Weight g	Probe Rinse End Weight g	Mass Gained on Probe g	Combined Total Mass Gained g
Run 1	310735	0.14820	0.17190	0.02370	73.67200	73.67620	0.00420	0.02790

If total mass gained is less than the LOD then the LOD is reported

BLANKS								
Test	Filter & Probe Number	Filter Start Weight g	Filter End Weight g	Mass Gained Filter g	Probe Start Weight g	Probe End Weight g	Mass Gained Probe g	Combined Total Mass Gained g
Run 1	31036	0.15010	0.15010	0.00000	64.80390	64.80420	0.00030	0.00050

If total mass gained is less than the LOD then the LOD is reported

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 1 — TPM

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	mm Hg	763.51
Stack static pressure, P_{static}	mm H_2O	8.36
$P_s = \frac{P_b + (P_{static})}{13.6}$	mm Hg	764.12
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	51.8
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0645428
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.769
Gas meter correction factor, Y_d		1.095
Mean dry gas meter temperature, T_m	°	18.867
Mean pressure drop across orifice, DH	mmH_2O	68.214
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m + 273}$	m^3	0.796
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.8603
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$		
Is the process burning hazardous waste? *(if yes, no favourable oxygen correction)*		No
% oxygen measured in gas stream, act%O_2		18.0
% oxygen reference condition		21
O_2 Reference Factor $O_2\ Ref = \frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0750
	%	7.50
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Pitot tube velocity constant, K_p		34.97
Velocity pressure coefficient, C_p		0.88
Mean of velocity heads, DP_{avg}	mm H_2O	9.06
Mean square root of velocity heads, ÖDP		3.01
Mean stack gas temperature, T_s	°C	67
$V_s = \frac{(K_p)(C_p)(ÖDP)(Ö(T_s + 273))}{(M_s)(P_s)}$	m/s	11.64

Molecular weight of dry gas, M_d		
CO_2	%	1.73
O_2	%	18.00
Total	%	19.73
N_2 (100 -Total)	%	80.27
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.00
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.17
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.79
$Q_a = (60)(A_s)(V_s)$	m^3/min	548.5
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) +273}$	Dry	409.9
$Q_{std02} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) +273}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) +273}$	Wet	443.13
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	7.81
Nozzle area, A_n	mm^2	47.91
Total sampling time, q	min	32
$\%I = \frac{(4.6398E6)(T_s+273)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	99.5
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.02370
Mass collected in probe, M_p	g	0.00420
Total mass collected, M_n	g	0.02790
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m³	32.430
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m³	35.060
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m³	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		862.25

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER QUALITY ASSURANCE CHECKLIST

LEAK RATE						
Run	Mean Sampling Rate litre/min	Pre-sampling Leak Rate litre/min	Post-sampling Leak Rate litre/min	Maximum Vacuum mm Hg	Acceptable Leak Rate litre/min	Leak Tests Acceptable?
Run 1	26.29	0.21	0.26	-304.8	0.53	Yes

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	99.46	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.58	2.5	Yes

The above is based on both the Filter and rinse uncertainty

BLANK VALUE				
Run	Overall Blank Value mg/m³	Daily Emission Limit Value mg/m³	Acceptable Blank Value mg/m³	Overall Blank Acceptable mg/m³
Blank 1	0.58	50	5.0	Yes

FILTERS					
Run	Filter Material	Filter Size mm	Max Filtration Temperature °C	Pre-use Filter Conditioning Temperature °C	Post-use Filter Conditioning Temperature °C
Run 1	Quartz Fibre	47	68	180	160

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Isokinetic							
Test Number	Sampling Time and Date	Start Weight kg	End Weight kg	Total gain kg	Concentration %	LOD %	Uncertainty %
Run 1	07:18 - 07:53 13 June 2018	4.3450	4.3968	0.0518	7.5	0.01	2.8

Moisture Quality Assurance							
Test Number	Sampling Duration mins	Total Volume Sampled l	Sampling Rate l/min	Start Leak Rate l/min	End Leak Rate l/min	Acceptable Leak Rate l/min	Leak Tests Acceptable?
Run 1	32	860	26.3	0.21	0.26	0.53	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	1.00	m
Stack Width, W	-	m
Stack Area, A	0.79	m^2
Average stack gas temperature	67	°C
Stack static pressure	0.088	kPa
Barometric Pressure	101.8	kPa

Stack Gas Composition & Molecular Weights								
Component	Molar Mass M	Density kg/m³ p	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m³ pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m³ pi
CO_2	44	1.963059	1.728571	0.017286	0.033933	1.598890	0.015989	0.031387
O_2	32	1.427679	18.000000	0.180000	0.256982	16.649595	0.166496	0.237703
N_2	28	1.249219	80.271429	0.802714	1.002766	74.249267	0.742493	0.927536
H_2O	18	0.803070	-	-	-	7.502248	0.075022	0.060248

Where: p = M / 22.41 pi = r x p

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2937	kg/m^3
Wet Density (STP), P_{STW}	1.2569	kg/m^3
Dry Density (Actual), P_{Actual}	1.0448	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.015	kg/m^3

Where:

P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

P_{STW} = (P_{STD} + pi of H_2O) / (1 + (pi of H_2O / 0.8036))

$P_{Actual} = P_{STD}$ x (Ts / Ps) x (Pa / Ta)

$P_{ActualW} = P_{STW}$ x (Ts / Ps) x (Pa / Ta)

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

TRAVERSE 1

Date of Survey	13 June 2018
Time of Survey	07:02
Velocity Measurement Device:	S-Type Pitot

Sampling Line A								
Traverse Point	Distance into duct (m)	DP pt mmH_2O (average of 3 readings)	DP pt Pa (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.15	7.8	76	67	10.6	8.3	-	<15
2	0.85	10.5	103	67	12.4	9.7	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	9.1	89	67	11.5	9.0	-	-

Sampling Line B								
Traverse Point	Distance into duct (m)	DP pt mmH_2O (average of 3 readings)	DP pt Pa (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.15	8.3	81	67	11.0	8.6	-	<15
2	0.85	10.0	98	67	12.1	9.5	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	9.1	89	67	11.5	9.0	-	-

PRELIMINARY STACK SURVEY QUALITY ASSURANCE CHECKLIST

PITOT LEAK CHECK								
Run	Pre Traverse Leak Rate				Post Traverse Leak Rate			
	Start Value Pa	End Value Pa	Difference %	Outcome	Start Value Pa	End Value Pa	Difference %	Outcome
Run 1	145	145	0.0	Pass	130	130	0.0	Pass

To complete a compliant pitot leak check a pressure of over 80 mmH_2O (or 800 Pa) is applied and the pressure drop monitored over 5 mins. A drop of less than 5% must be observed.

S-Type Pitot Stagnation Check				
Run	Stagnation (Pa)	Reference (Pa)	Difference (Pa)	Outcome (Permitted +/- 10 Pa)
Run 1	80	80	0.0	Pass

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria				
EA Technical Guidance Note (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Differential Pressure	76	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	10.6	m/s	-	-
Highest Gas Velocity	12.4	m/s	-	-
Ratio of Gas Velocities	1.2	-	< 3 : 1	Yes
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes
No local negative flow	Yes	-	-	Yes

Calculation of Stack Gas Velocity, V		
Velocity at Traverse Point, $V = K_{pt} \times (1\text{-}e) * \sqrt{(2 * DP_{pt} / P_{ActualW})}$		
Where: K_{pt} = Pitot tube calibration coefficient (1-e) = Compressibility correction factor, assumed at a constant 0.998		
Average Stack Gas Velocity, Va	11.5	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	67	0	°C
Total Pressure	101.888	101.3	kPa
Oxygen	18.0	21	%
Moisture	7.50	7.50	%
Pitot tube calibration coefficient, K_{pt}	0.88		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	11.49	m/s
Stack Area (A)	0.79	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	32502	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	26248	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	24279	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	26248	m^3/hr

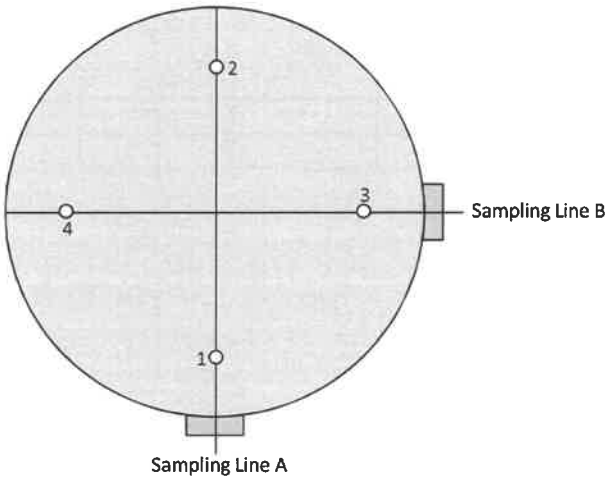
Where:
Q_{Actual} = Va x A x 3600
Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600
$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600
Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((20.9 - O_2a) / (20.9 - O_2s))

Nomenclature:
Ts = Absolute Temperature, Standard Conditions, 273 K
Ps = Absolute Pressure, Standard Conditions, 101.3 kPa
Ta = Absolute Temperature, Actual Conditions, K
Pa = Absolute Pressure, Actual Conditions, kPa
Ma = Water vapour, Actual Conditions, % Vol
Ms = Water vapour, Reference Conditions, % Vol
O_2a = Oxygen, Actual Conditions, % Vol
O_2s = Oxygen, Reference Conditions, % Vol

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK DIAGRAM

	Value	Units
Stack Depth	1.00	m
Stack Width	-	m
Area	0.79	m^2



- Isokinetic sampling point
- Isokinetic sampling points not used
- Non Isokinetic/Gases sampling point

Non-Isokinetic/Gases Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack	Units
-	-	-	-

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	14.6	0.15	< 15
2	85.4	0.85	< 15
3	14.6	0.15	< 15
4	85.4	0.85	< 15
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

SAMPLING LOCATION

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - TOTAL PARTICULATE MATTER

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Limit of Detection	Leak	Uncollected Mass
	m^3	K	kPa	% by volume	% by volume	% by mass	%	mg
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 5% of ELV**	**≤ 2%**	**≤ 10% of ELV**
Run 1	0.001	2.0	0.50	1.0	N/A	0.5000	-	-
as a %	0.13	0.59	0.49	1.0	N/A	1.16237	0.99	0.001
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**	**Yes**

Run	Volume (STP)	Mass of particulate	O_2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.64	27.9000	1.0	0.185	0.0003	-
MU as mg/m^3	0.41	0.5812	-	0.185	0.0003	**0.74**
MU as %	1.27	1.7921	-	0.571	0.0010	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**1.47**	**mg/m^3**	**4.54**	**%**

(k is a coverage factor which gives a 95% confidence in the quoted figures)
Reference – SOCOTEC UK Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume m^3	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 2%**
Run 1	0.001	2.0	0.50	1.0	N/A	-
as a %	0.13	0.59	0.49	1.0	N/A	0.99
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**

Run	Volume (STP) m^3	Mass Gained mg	O_2 Correction -	Leak mg/m^3	Uncollected Mass mg	Combined uncertainty
Run 1	0.64	51800	1.0	371.64	58	-
MU as % v/v	0.10	0.02	-	0.05	0.009	**0.12**
MU as %	1.27	0.19	-	0.57	0.11	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.23**	**% v/v**	**2.82**	**%**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	11.5	m/s
Measured Volumetric Flow rate at Actual Conditions	32502	m³/hr

Performance Characteristics & Source of Value	Units	Values	Requirement	Compliant
Uncertainty of Local Gas Velocity Determination				
Uncertainty of pitot tube coefficient	-	0.010		
Uncertainty of mean local dynamic pressures	-	0.36		
Factor loading, function of the number of measurements.	3 readings	0.591	minimum 3	Yes
Range of measurment device	pa	1000		
Resolution	pa	1.00		
Calibration uncertainty	pa	3.27	<1% of Value or 20 Pa whichever is greater	Yes
Drift	% range	0.10		
Linearity	% range	0.06	<2% of value	Yes
Uncertainty of gas density determination				
Uncertainty of molar mass determination	kg/mol	0.00003		
Uncertainty of temperature measurement	K	1.73	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	520		
Uncertainty associated with the estimate of density	-	0.008		
Uncertainty associated with the measurement of local velocity	-	0.0001		
Uncertainty associated with the measurement of mean velocity	-	0.0001		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.14
Expanded uncertainty at a 95% Confidence Interval	0.27

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Velocity at a 95% Confidence Interval	%
Expressed as a % of the Measured Velocity	1.2
Expanded uncertainty at a 95% Confidence Interval	2.3

Measurement Uncertainty Volumetric Flow Rate	m³/hr
Combined uncertainty	845
Expanded uncertainty at a 95% Confidence Interval	1656

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Volumetric Flow Rate at a 95% Confidence Interval	%
Expressed as a % of the Measured Volumetric Flow Rate	2.6
Expanded uncertainty at a 95% Confidence Interval	5.1

Reference – SOCOTEC UK Technical Procedure AE150 Estimation of Uncertainty of Measurement

END OF REPORT

Thank you for choosing SOCOTEC UK for your environmental monitoring needs. We hope our services have met your requirements and that you are fully satisfied with your experience of working with us, we really do value your custom and would welcome your feedback. We would appreciate it if you could take a moment to complete a short online questionnaire so that we can improve our operations and address any areas that have not met with your expectations, by clicking on the following

https://www.surveymonkey.co.uk/r/CAE_customer_feedback_weblink